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(58) Field of search
UK CL (Edition K) B5N
INT CL[5] B32B

(54) **Constructional composite resin impregnated fibrous material**

(57) Resin impregnated fabrics are made from reinforcement fibres of e.g. glass, carbon or polyaramides. The fabrics are produced by the superposition of the fibres, in preferred orientations, to form a complete unit using a single multidirectional weaving process, and are used in the manufacture of beams, sectional elements and structural frames. The fibres of the layers are arranged in three or more different directions and the layers are joined together to form a compact system using a small chain of binding stitches formed from thread of similar or different composition, applied by a general warp stitch method.

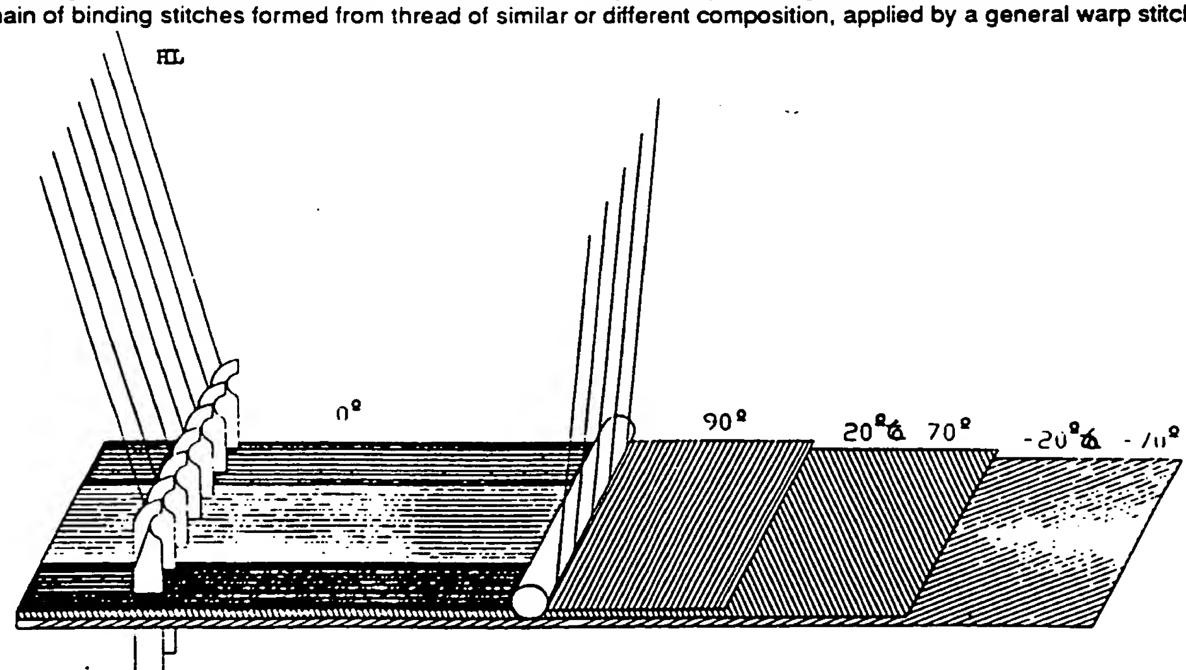

FIG. I

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MULTILAYERED, MULTIDIRECTIONAL FABRICS OF VARIABLE COMPOSITION USED AS REINFORCEMENT STRUCTURES FOR USE IN THE MANUFACTURE OF BEAMS, SECTIONAL ELEMENTS AND FRAMES MADE FROM COMPOSITE MATERIALS

Field of the Invention

The present invention relates to structures made from fibres for reinforcing composite materials, in the form of multi-layered, multi-directional fabrics of variable composition for use in the manufacture of beams, sectional elements and frames, especially in the automobile and/or transport industries. However, the invention may be applicable to the manufacture of structural elements in civil and/or mechanical engineering generally.

Background of the Invention

Composite materials formed by combining reinforcement fibres and/or fabrics with a polymer matrix, of a thermoplastic or thermostable type, are conventionally produced by processes involving the lamination, using resins, of multiple layers of fabric formed by a warp and a weft whereby the fibres of the fabric are arranged in orthogonal directions ($0^{o}/90^{o}$). In the case of components which are subjected to considerable stresses in directions other than these orthogonal directions, it is customary to form the lamination by so orientating and

cutting conventional fabrics as to lie in other directions in which extraordinary stresses may be exerted.

This layer-by-layer lamination process, which involves the additional steps of cutting and orientating the fabrics, is difficult to implement and labour intensive, and consequently results in low productivity, and the process becomes extremely difficult to implement when, in addition, it is necessary to combine fibres having different compositions, in different directions so as to meet design and operational criteria required by the components made from the composite, laminated materials.

These difficulties are apparent, for example, in the construction of the chassis and frames of cars and/or light or heavy transport, which are comprised of stringers and cross-members in the form of beams having a variety of differently profiled sections of substantial thickness, or in the form of single frame structures made from composite materials. In this case, the structures are extremely complicated because the parts concerned are subjected to high mechanical stresses due to compression, traction in many different directions, vibrations, etc., the requirement being for a structure which is made from fabrics having fibres which are oriented in several directions, e.g. $0^{o}/90^{o}/+45^{o}/-45^{o}$, relative to the

long axis (0^{o}) of the vehicle. Also, there may be an additional requirement for hybrid systems, made from fibres, and/or combinations of fibres, which have different mechanical characteristics in different directions, or at different angles. This additional complexity usually results in a substantial increase in the production costs, making the large scale production of mechanical parts impractical, but technically feasible and desirable, in order to achieve a considerable reduction in the weight of the systems in question.

Summary of the Invention

The present invention provides a very significant contribution to complex lamination processes used in the manufacture of highly mechanically stressed parts such as beams, stringers, cross-members or flat structures for motor vehicle chassis, provides a solution to technically complex problems, and enables a considerable reduction in manufacturing costs due to the fact that automation is possible.

According to the invention there is provided a system of multi-layered fibres having preferred orientations, in accordance with the requirements imposed by mechanical stress, simple or multiple, by the composition of the fibres in each of the layers, which are joined together by

warp stitching to form the system, the dimensions of which are in keeping with those of the beams, cross-members, stringers or sectional elements which form the construction under consideration.

Brief Description of the Drawings

For a better understanding of the invention reference is made to the accompanying drawings in which:

Figure 1 shows a multilayered fabric joined together by binding threads;

Figures 2 and 3 illustrate consecutive steps in the production of a channel-shaped stringer or beam; and

Figure 4 shows a component which can be used as a stringer, beam or cross-member or as a complete assembly in the form of a frame for chassis in the drive heads of motor vehicles and/or load-bearing structures for heavy or light transport.

Detailed Description of the Preferred Embodiment of the Invention.

By way of illustration, and as one of many examples, without in any way limiting the scope of the present invention for multilayered, multi-angled systems, of

uniform or variable composition, depending on the area or direction of the mechanical stresses in said applications, the invention is defined by the following characteristics:

In a multilayer reinforcement fibre system, one layer of fibres is defined as being orientated at 0^{o}, this orientation being along the long axis of the component, as will be described hereinafter; another layer of reinforcement fibres is orientated at an angle of 90^{o} to the first layer (at 0^{o}); another layer of reinforcement fibres is orientated at an angle in the range from $+20^{o}$ to 70^{o} (e.g. + 45^{o}) with respect to 0^{o} and another layer of reinforcement fibres is orientated at an angle in the range from -20^{o} to -70^{o} (e.g. -45^{o}) with respect to 0^{o}, the layers being joined together by means of binding threads (HL) applied by the warp stitching method or Ketten system in a single operation so as to form a single, multilayered fabric ($0^{o}/90^{o}/+45^{o}/$ -45^{o}) (Figure 1), the composition of which is defined as follows:-

In the 0^{o} direction, a strip of multifilament glass threads is positioned between two lateral regions of multifilament threads made from carbon fibre, or being arranged alternately with the glass strips (Figure 1); the said carbon fibre strips having the required width and

thickness to coincide with the regions in which greater tensile and flexural modulus of elasticity is required.

Direction 90^{o}: glass fibre multifilament threads (Figure 1).

Direction +45^{o}: glass fibre multifilament threads (Figure 1).

Direction -45^{o}: glass fibre multifilament threads (Figure 1).

The dimensions of the assembly, and in particular those of the strips containing carbon fibre, applied in the development of a stringer or channel-shaped beam are shown in Figures 2 and 3, and it should be understood that the dimensions of the side and end walls of the beam are not restrictive conditions for the system.

This basic unit of a multi-layered, multi-angled fabric, 0.80 mm thick, is impregnated with an epoxy-based matrix resin, which is applied by rollers in a continuous automated or manual process, and is constituted by 52 parts of diglycidyl diphenol A, 45 parts of nadic methyl anhydride and 2 parts of 2-(dimethylaminomethyl) phenol, the relative proportions by weight of the fibres and the

resin being 66% and 34% respectively. This multilayered structure is subsequently built up, or developed, on a mould to form a continuous frame having a thickness of about 20 mm. While the structure is on the mould, and is being compressed (using by a vacuum or hydraulic press), it is made to undergo a curing cycle having the following temperature characteristics;

1 hour at 90°C

3 hours at 120°C

3 hours at 160°C

to yield a component or components which may subsequently be used as stringers, beams, cross-members or as a complete frame-shaped unit for a chassis (Figure 4) in automobile traction heads and/or load bearing structures, for heavy or light transport, in which the 0° direction, containing the carbon fibre strips, is aligned with the longitudinal direction of the chassis or stringers, the latter being subjected to the greatest mechanical stress, and wherein the fibres in the other directions provide complementary reinforcement to meet stresses in shear and torque etc. The process is automated, and offers the particular advantage that the carbon fibre can be incorporated in the required direction, position and quantity to meet the considerable mechanical stresses to which the component is subjected.

In contrast, a component having similar mechanical characteristics can be made from standard fabrics by interweaving glass fibres in the warp and weft directions (i.e. 0^{o} and 90^{o} direction) for loading in those directions. The requirement to deal with shear stresses in the 45^{o} direction can be met using the same ($0^{o}/90^{o}$) fabric by cutting, patching and subsequently orientating the fabric, automation of this process being impossible, and by providing longitudinal carbon fibre reinforcement by laminating unidirectional filaments between successive layers of fabric. The entire process has to be carried out manually, and takes five times longer than the process of the invention; accordingly the cost and productivity do not make the process viable for mass production in the automobile, transport, etc., industries.

Although the description and the drawings illustrate the preferred embodiment of the invention, persons skilled in the art will realize that it is possible to introduce various modifications in the reinforcement fibre structures described hereinbefore without departing from the invention, as defined in the accompanying claims.

CLAIMS

1. A composite material reinforcement fibre structure, formed as a number of layers arranged in three or more different directions and joined together as a compact system by a small chain of binding thread, having the same or a different composition, applied using the warp stitch system, the structure being applied to the construction of structural elements in civil and/or mechanical engineering, and more particularly to the construction of motor vehicle and/or transport chassis, the said reinforcement fibre structure being prepared by impregnation using a thermoplastic or thermosetting matrix material, the processing and curing of which enables a component to be used in the said applications, the material used for the reinforcement fibres being selected from glass, carbon, polyaramide and other materials having similar properties.

2. A compact multidirectional structure of reinforcement fibres according to claim 1, wherein the fibres or threads are arranged with the following orientations: a layer at a defined orientation of 0°; another layer forming an angle of 90° relative to the defined orientation; a layer forming an angle in the range from 20° to 70° relative to the defined

orientation, and another layer forming an angle in the range from -20° to -70° relative to the defined orientation, the structure being for use in automobile and transport chassis and beams in civil engineering.

3. A compact multidirectional structure of reinforcement fibres according to claim 1 or claim 2, wherein the fibres or threads are preferably arranged in the following orientations: a layer with a defined orientation of 0°; another layer at an angle of 90° relative to the defined orientation, a layer at an angle of $+45^{\circ}$ to the defined orientation, and a layer at an angle of -45° to the defined orientation.

4. A compact multidirectional structure of reinforcement fibres according to any one of claims 1 to 3, wherein, in the 0° direction, glass and carbon fibres are assembled in strips which are of variable width and/or are arranged alternately and wherein, in the other directions, the layers preferably comprise glass fibre, the said 0° direction being coincident with the long dimension of a beam or chassis for use in civil or mechanical engineering generally.

5. A compact multidirectional structure of reinforcement fibres according to any one of claims 1 to

4, adapted to be impregnated with a synthetic resin of a thermoplastic or thermosetting type, being formed by the application of pressure and temperature following its development in a mould and providing sectional elements, beams, chassis and, generally, structures for civil and mechanical engineering.

6. A compact multidirectional structure of reinforcement fibres according to claim 1, having directions defined at 0°, $+45^{\circ}$ and -45°, wherein the 0° direction is coincident with the long direction of the multilayered structure, and which combines glass and carbon fibres or threads in strips which are of variable width and/or are arranged alternately, and which all have the same orientation, the fibres or threads in the other two directions being glass fibre.

7. A compact multidirectional structure of reinforcement fibres according to any one of the foregoing claims, for use in the manufacture of composite materials of elements for automobile and/or transport chassis.

8. A compact multidirectional structure of reinforcement fibres substantially as hereindescribed with reference to the accompanying drawings.

(0548H)

Amendments to the claims have been filed as follows

1. A composite material reinforcement fibre structure formed as the lay-up of continuous tows of reinforcing fibres arranged in three or more different directions, each layer of the structure corresponding to only one direction or orientation of reinforcing fibres, so as to define an independent plane (one plane per orientation), without interlacing with a neighbouring layer or layers and the layers being joined together by a small chain of binding thread wherein orientation of the reinforcing fibres, their lay-up in different planes and their binding by means of the stitching thread are carried out in a single process, the formed compact multidirectional structure being free from crimping and free from interlaced fibres; and being applicable to the construction of a motor vehicle and/or transport chassis, the said reinforcement fibre structure being prepared by impregnation using a thermoplastic or thermosetting matrix material, the processing and curing of which enables a component to be used in said applications, the material used for the reinforcement fibres being selected from glass, carbon, polyaramide and other materials having similar properties.

2. A compact multidirectional structure of reinforcement fibres according to claim 1, wherein the fibres or threads are arranged with the following orientations: a layer at a defined orientation of 0°; another layer forming an angle of 90° relative to the defined orientation; a layer forming an angle in the range from 20° to 70° relative to the defined

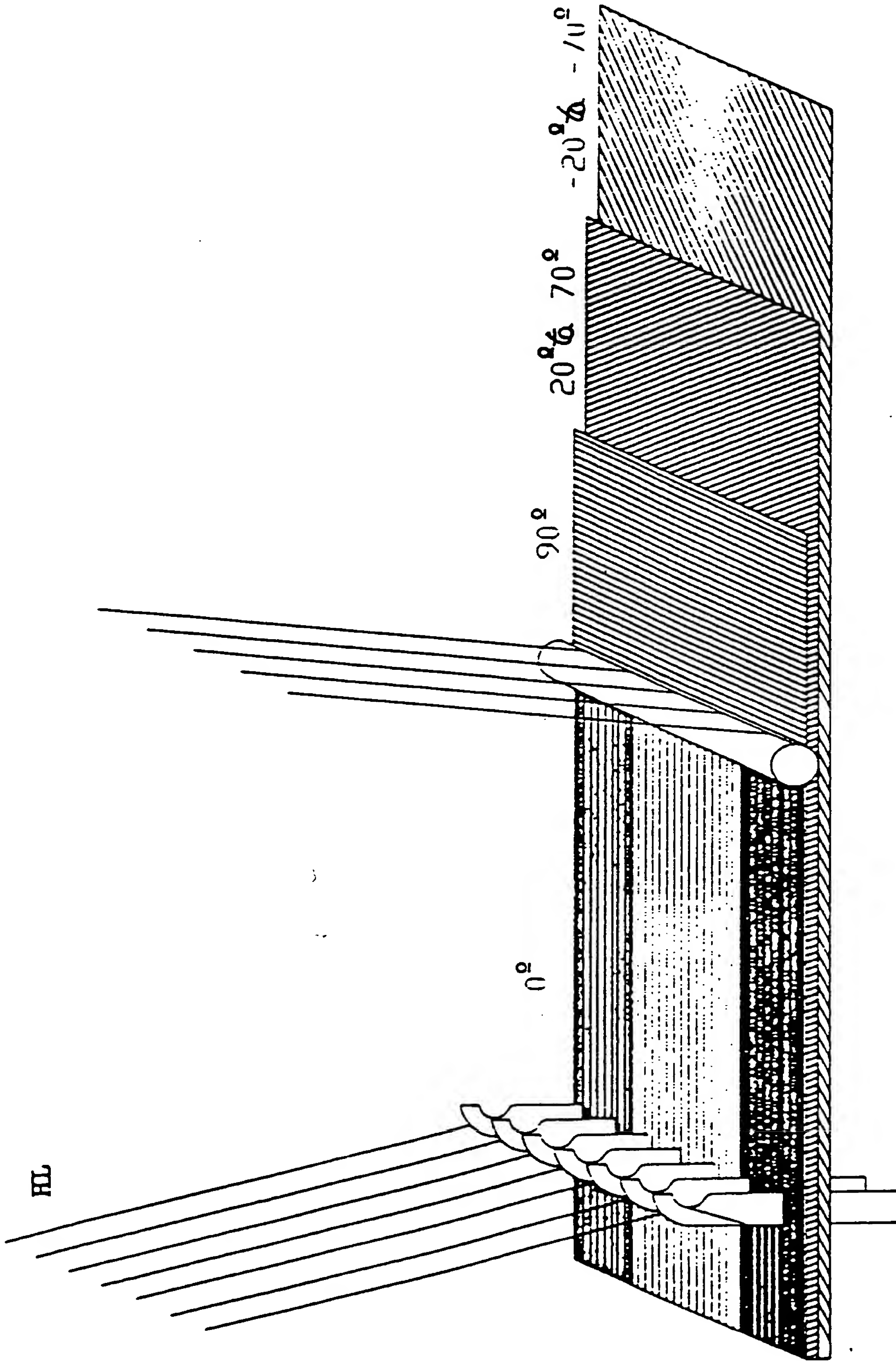

FIG. 1

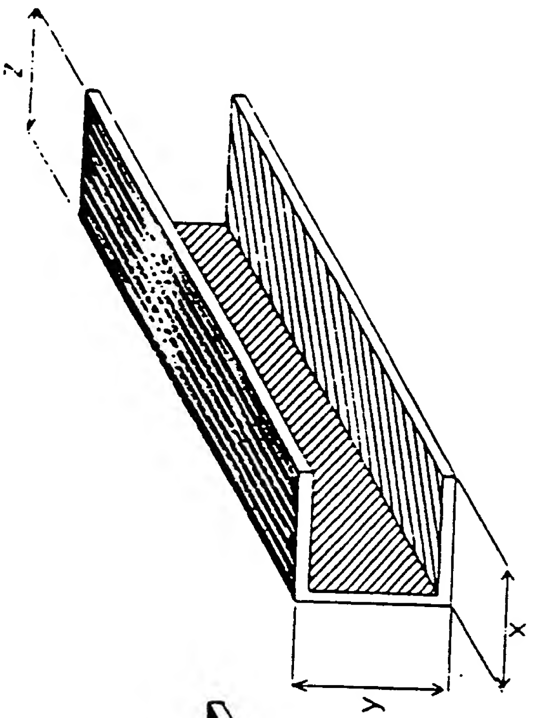

FIG. 3

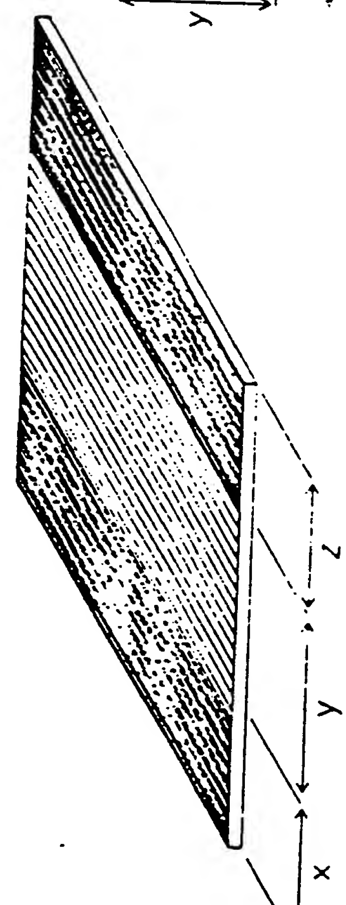

FIG. 2

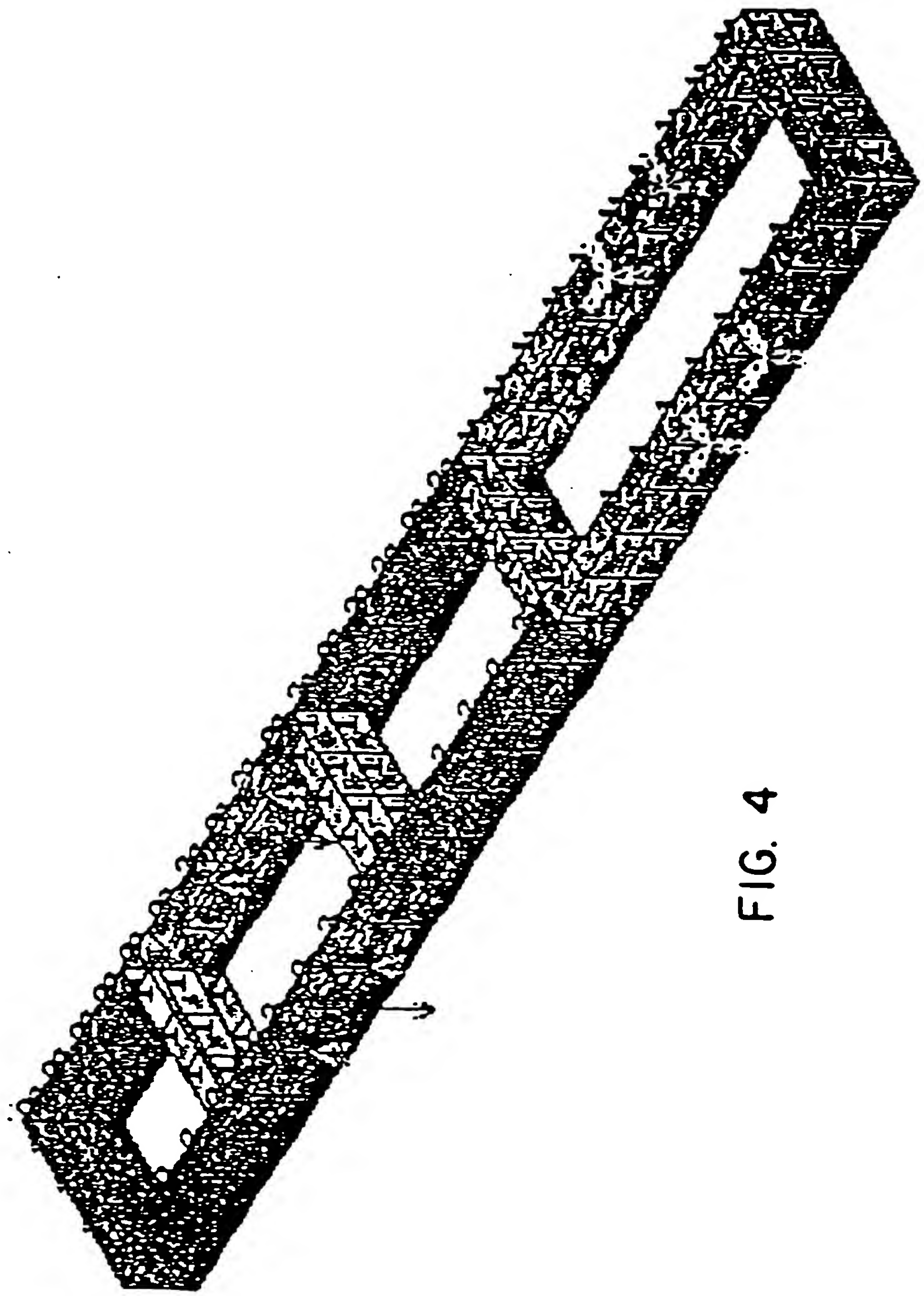

FIG. 4

Patents Act 1977
Ex .iner's report to the Comptroller under Section 17 (The Search Report)

Application number
9111325.8

Relevant Technical fields

(i) UK Cl (Edition K) B5N

(ii) Int Cl (Edition 5) B32B

Databases (see over)

(i) UK Patent Office

(ii)

Search Examiner

P N DAVEY

Date of Search

25 SEPTEMBER 1991

Documents considered relevant following a search in respect of claims 1-8

Category (see over)	Identity of document and relevant passages	Relevant to claim(s)
X	EP 0073648 A1 (TORAY) see eg Claim 2	1 at least

Category	Identity of document and relevant passages	Relevant to claim(s)

Categories of documents

X: Document indicating lack of novelty or of inventive step.

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